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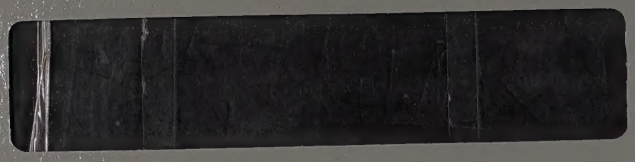

INSTRUCTION MANUAL

401

MODEL 401
FUNCTION GENERATOR

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SYSTRON DONNER
A MEMBER OF THE THORN EMI GROUP

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OF
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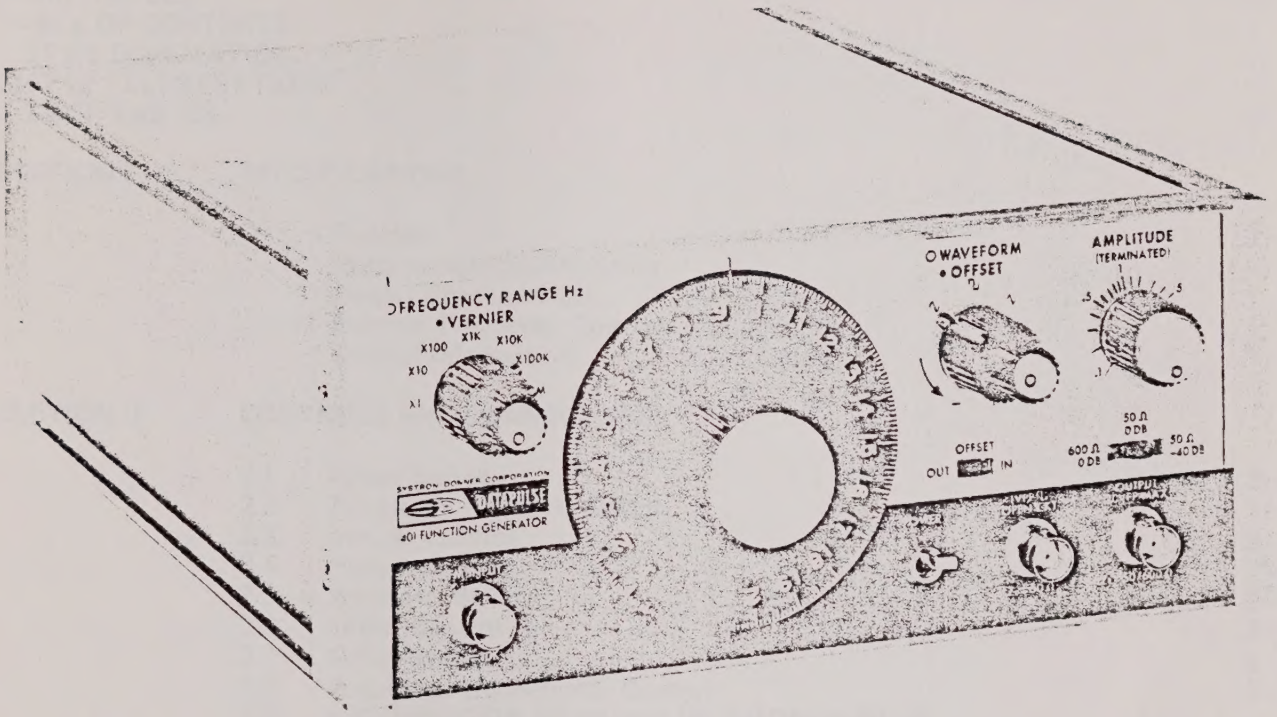

MODEL 401 FUNCTION GENERATOR

The Model 401 Function Generator is a highly versatile and reliable laboratory instrument capable of generating sine, square and triangle waveforms over a frequency range of from 0.02 Hz to 2 MHz. The output voltage is 20 volts peak-to-peak maximum, open circuit, (10 volts peak-to-peak into 50 ohms) with a dynamic amplitude range of 80 dB. Sine distortion is less than 0.25% over the audio range and less than 0.5% up to 200 kHz. An FM input is provided for external frequency control. Front panel controls provide for waveform offset and selectable output impedance of 50 or 600 ohms. A 1 volt peak-to-peak square wave output is provided for synchronization and calibration.

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TABLE OF CONTENTS

		PAGE
TITLE PAGE		i
FRONTISPIECE		iii
TABLE OF CONTENTS		v
LIST OF SCHEMATICS		vi
LIST OF ILLUSTRATIONS		vi
LIST OF TABLES		vi
SECTION I	SPECIFICATIONS	
	Function	1-1
	Performance Characteristics	1-1
	Output Characteristics	1-1
	External Frequency Control	1-1
	General Information	1-1
SECTION II	CONTROLS AND CONNECTORS	
2.1	Power Switch	2-1
2.2	Frequency Range Hz Switch	2-1
2.3	Vernier Control	2-1
2.4	Frequency Dial	2-1
2.5	Waveform Switch	2-1
2.6	Offset Control	2-1
2.7	Offset Switch	2-1
2.8	Amplitude (terminated) Control	2-1
2.9	600 Ohms/0 DB, 50 Ohms/0 DB, 50 Ohms/-40 DB (Impedance/Attenuator) Switch	2-1
2.10	1 V PP ⅂Connector	2-1
2.11	Output Connector	2-1
2.12	FM Input Connector	2-1
2.13	Line Voltage (115/230) Selector	2-1
SECTION III	OPERATION	
3.1	Equipment (or equivalent) Required	3-1
3.2	Output Waveform Verification	3-1
SECTION IV	MAINTENANCE	
4.1	Preventive Maintenance	4-1
4.2	Parts Replacement	4-1
4.3	Calibration	4-2

PAGE

SECTION IV (cont.)

4.4 Specification Verification 4-9
4.5 Troubleshooting 4-12

SECTION V THEORY OF OPERATION

5.1 General Description 5-1
5.2 Circuit Description 5-1

SECTION VI PARTS LIST

6.1 Abbreviations and Symbols 6-1
6.2 Front Panel Assembly 6-2
6.3 Back Panel Assembly 6-2
6.4 Frequency Range Switch Assembly 6-2
6.5 Waveform Switch Assembly 6-3
6.6 Printed Circuit Board Assembly 6-3

LIST OF SCHEMATICS

Drawing Number	Description
41000-222	Block Diagram – Model 401
40000-410	Schematic – Function Generator
37000-883	Schematic – PCB Assembly
40000-395	Schematic – Power Supply

LIST OF ILLUSTRATIONS

Figure Number	Title	
2-1	Model 401 Controls and Connectors	2-2
4-1	Top View – Model 401	4-3
4-2	Bottom View – Model 401	4-4

LIST OF TABLES

4-1	Dial Accuracy Check	4-10
4-2	Troubleshooting	4-13

SECTION I

SPECIFICATIONS

FUNCTION: sine, square and triangle.

PERFORMANCE CHARACTERISTICS

Frequency Range: 0.02 Hz to 2 MHz in 7 ranges.

Dial Accuracy:

<±1% of dial setting from 2 Hz to 200 kHz.
<±2% of dial setting from 200 kHz to 2 MHz.
<±2% of range from 0.2 Hz to 2 Hz.

Frequency Vernier: approximately 1% of full scale (2 minor dial divisions).

Time Symmetry (all waveforms):

>99.5% to 200 kHz.
>98% to 2 MHz.

Frequency Stability:

<±0.05% for 1 hour.
<±0.5% for 1 month.

Sine Distortion:

<0.25%, 2 Hz to 20 kHz.
<0.5%, 0.2 Hz to 200 kHz.
<3%, 200 kHz to 2 MHz.

Sine Frequency Response: reference 1 kHz at maximum amplitude into 50 ohms.

<±1% to 200 kHz.
<±3% to 2 MHz.

Square Wave Rise/Fall Time: <40 ns.

Square Wave Aberrations: <±5%.

OUTPUT CHARACTERISTICS

Amplitude: >20 V p–p maximum, open circuit.

Amplitude Range: 80 dB (1 mV p–p to 10 V p–p into 50 ohms).

Stability (amplitude): <±0.1% for 1 hour.

DC Offset: ±10 V, open circuit, ±5 V, terminated. (Combination of output amplitude and offset not to exceed ±10 V open circuit or ±5 V terminated.)

Sync Amplitude: 1 V p–p, ±1%, open circuit.

Power: >500 mW maximum into 50 ohms.

Impedance: 50 or 600 ohms, selectable by front panel switch.

EXTERNAL FREQUENCY CONTROL

Input: DC coupled, approximately 25 mV input for 1 minor dial division deviation (4.5 V for 0.2 to 2 dial deviation).

Input Impedance: 10 k ohms.

Range: >1000:1.

GENERAL INFORMATION

Power Required: approximately 12 W, 50–60 Hz at 105–125/210–250 V ac selectable by means of a multitap transformer and a range switch on the back panel.

Operating Temperature: 0 to 50° C. All specifications guaranteed over an ambient temperature range of 18° to 28° C, after ½ hour warm-up.

Weight: approximately 7.5 pounds.

Shipping Weight: approximately 10 pounds.

Dimensions: 8-3/8" W x 3½" H x 12-5/8" D (cabinet less knob projections, 11-1/8" D).

SECTION II

CONTROLS AND CONNECTORS

The Model 401 controls and connectors are identified and described in this section (see Figure 2-1).

2.1 POWER Switch

Applies ac voltage to the primary of the power transformer.

2.2 FREQUENCY RANGE Hz Switch

Selects one of seven available frequency ranges.

2.3 VERNIER Control

Makes fine frequency adjustments. When the VERNIER control is in the CAL position, the output frequency is equal to the product of the frequency dial and the range switch settings.

2.4 Frequency Dial

Varies frequency within the range selected by the FREQUENCY RANGE Hz switch.

2.5 WAVEFORM Switch

Selects the output waveform to be either sine (∿), square (⊓), or triangle (△).

2.6 OFFSET Control

Adjusts the output waveform offset in either a positive (+) or negative (-) direction.

2.7 OFFSET Switch

In the NAR position, the OFFSET control makes only fine adjustments of the output waveform offset. In the WIDE position, the output waveform offset can be continuously adjusted from positive (+) to negative (-) 10 volts by the OFFSET control.

2.8 AMPLITUDE (terminated) Control

Continuously adjusts the amplitude of the sine, square and triangle waveforms. Values on the front panel indicate the approximate voltage output when the instrument is properly terminated (50 or 600 ohms).

2.9 600 OHMS/0 DB, 50 OHMS/0 DB, 50 OHMS/-40 DB (Impedance/-Attenuator) Switch

Selects the output impedance and attenuation.

2.10 1 V PP⊓Connector

Provides a 1 volt peak-to-peak square wave output for synchronization and calibration purposes.

2.11 OUTPUT Connector

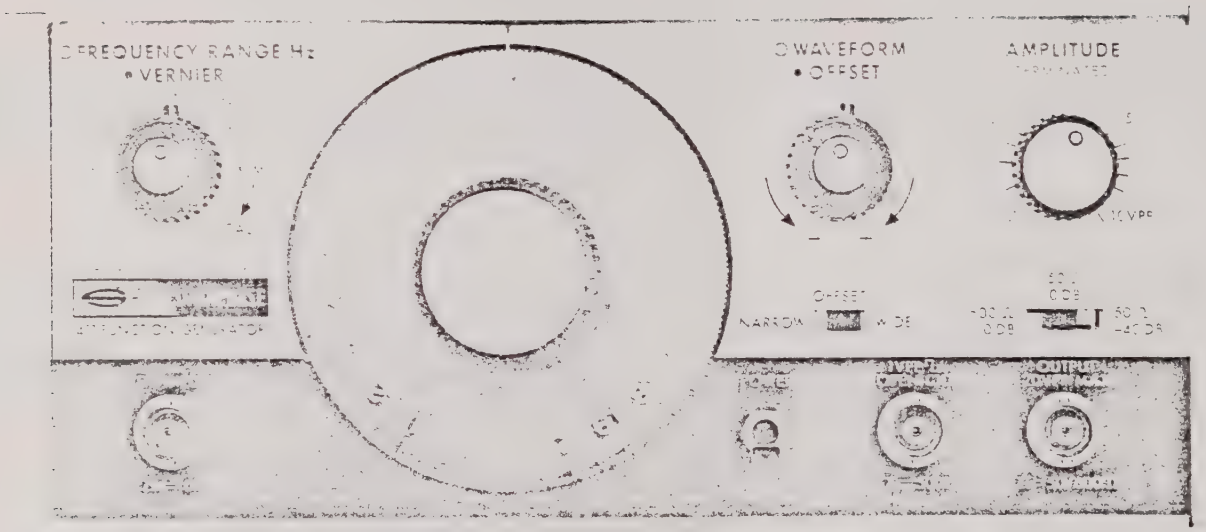
Main output for the sine, square or triangle waveform.

2.12 FM INPUT Connector

Input for an external frequency modulation signal.

2.13 LINE VOLTAGE (115/230) Selector

Selects the transformer primary configuration for either 115 or 230 volts ac.



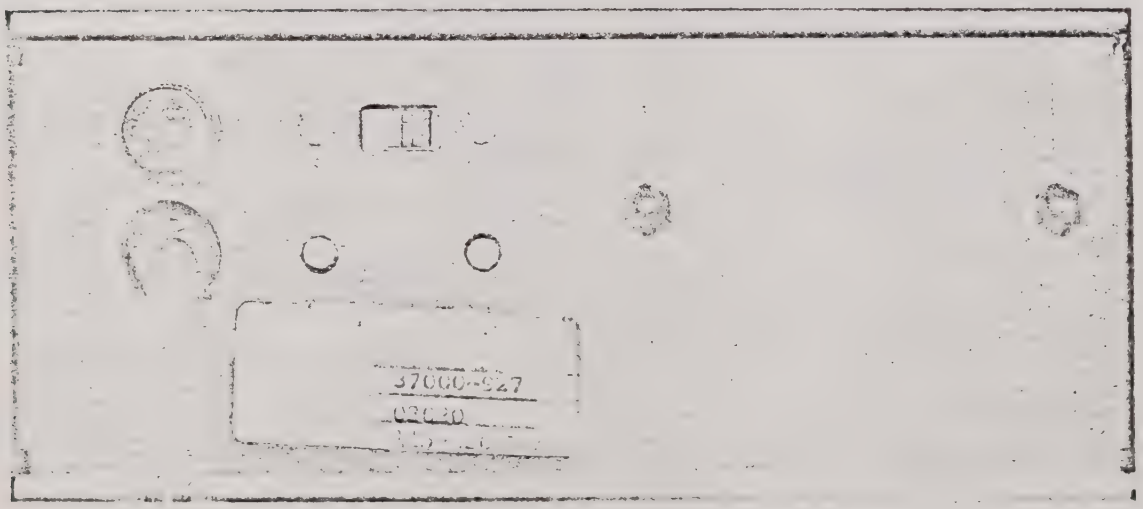


Figure 2-1. Model 401 Controls and Connectors.

SECTION III

OPERATION

The following procedure provides a brief operational check of the function generator and an introduction to its controls.

3.1 EQUIPMENT (or equivalent) REQUIRED

a. Oscilloscope with a band-pass capability of dc to 50 MHz. Tektronix 546 with a Type 1A2 plug-in recommended.

b. Variable low voltage dc source capable of at least 5 volts output.

c. Fifty ohm, 5 watt termination. Tektronix 011-0099-00 recommended.

d. Two 50 ohm coaxial cables terminated with BNC connectors.

3.2 OUTPUT WAVEFORM VERIFICATION

a. Actuate the POWER switch to the "off" (down) position.

CAUTION

Verify that the 115/230 volt slide switch on the back panel agrees with the line voltage prior to connecting the power plug.

b. Set the function generator controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X10 K
VERNIER	CAL
Frequency Dial	1
Impedance/Attenuator switch	50 OHMS/ 0 DB
AMPLITUDE	fully clockwise
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
WAVEFORM	sine (∿)

c. Actuate the POWER switch to the "on" (up) position and verify that the pilot light illuminates.

d. Connect the 1 V PP⊓ connector to the oscilloscope vertical input and verify that a square wave of approximately 1 volt peak-to-peak is displayed.

e. Disconnect the 1 V PP ⊓ connector from the oscilloscope vertical input and connect it to the trigger input. Set the oscilloscope for external triggering.

f. Connect the OUTPUT connector to the oscilloscope vertical input. Terminate with 50 ohms at the oscilloscope. Verify that a sine wave of approximately 10 kHz frequency and 10 volts peak-to-peak amplitude is displayed.

g. Vary the AMPLITUDE control from 0.1 to 10 V PP and verify that the amplitude of the displayed waveform changes accordingly.

h. Return the AMPLITUDE control to 10 V PP. Set the impedance/attenua-

tor switch to the 50 OHMS/-40 DB position.

i. Verify that the amplitude of the waveform decreases by a factor of 100.

j. Set the IMPEDANCE/ATTENUATOR switch to 600 OHMS/0 DB position. Verify that the amplitude of the waveform decreases by a factor of 13 with reference to 50 OHMS/0 DB position. Return the impedance/attenuator switch to 50 OHMS/0 DB.

k. Vary the frequency dial from the fully counterclockwise to the fully clockwise position and verify that the frequency changes accordingly.

l. Repeat step (h) for all frequency ranges.

m. Set the function generator controls the same as in step (b).

n. Set the WAVEFORM switch to square (⊓), then to triangle (⩘), and verify that the waveform changes accordingly.

o. Reduce the AMPLITUDE control to 3.

p. Set the OFFSET switch to WIDE and rotate the OFFSET control to the positive (+) position.

q. Verify that the waveform is shifted in a positive direction.

r. Rotate the OFFSET control to the negative (-) position and verify that the waveform is shifted in a negative direction.

s. Set the OFFSET switch to NAR and verify that the OFFSET control makes only fine offset adjustments of the waveform.

t. Connect the variable dc voltage source to the FM INPUT. Set the FREQUENCY RANGE Hz selector to X10 K and the frequency dial to 1.

u. Vary the dc voltage from 0 to 1 volt and verify that the output frequency increases to approximately 14 kHz.

v. Disconnect the voltage source from the FM INPUT.

SECTION IV

MAINTENANCE

4.1 PREVENTIVE MAINTENANCE

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Model 401 is a sensitive laboratory instrument and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Remove the top and bottom covers by removing 2 flat head Phillips screws on each cover. The side panels should normally be left on but may be taken off by removing two screws from the rear end block. Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the instrument is inoperative. Inspection intervals should be based on frequency of use and the severity of the environment to which the instrument is exposed.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene, using a soft cloth, and a cotton tipped applicator for narrow spaces.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time; 500 operating hours or six month intervals is recommended. Refer to paragraph 4.3 for complete calibration instructions.

4.2 PARTS REPLACEMENT

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Use only direct replacements for parts affecting performance. Transistors temporarily removed should be returned to their original sockets unless defective. Replacement of some parts will necessitate partial recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supplies and the output amplifier are mounted on the back panel and side rail for heat dissipation. Fiber bushings and mica washers are used to electrically insulate the case (collector) from the heat sink (ground) and a thin film of thermal compound (Wakefield No. 122) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Soldering

Only experienced technicians should replace soldered parts. Printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts:

a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge

or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.

b. Obviously defective parts may be clipped out so their leads can be conveniently unsoldered from the board.

c. Solder only on the circuit side of the board; not on the component side.

d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.

e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.

f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over, so that it can be straightened before it is pulled out.

g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a tooth pick or pointed tool.

h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.

i. Clean the area thoroughly after soldering.

4.3 CALIBRATION

Refer to Figures 4 - 1 and 4 - 2 for location of calibration adjustments and test points.

NOTE: To insure maximum performance and long term calibration, no adjustments should be made before a one-half hour warm-up period is complete. Since the warm-up period is to allow for internal temperature stabilization, the instrument top cover should be slid back only while actual adjustments are being made.

4.3.1 Equipment (or equivalent) Required

a. Oscilloscope with a bandpass capability of dc to 50 MHz. Tektronix 546 with a Type 1A2 plug-in recommended.

b. Digital voltmeter capable of reading units of millivolts. Systron-Donner 7000A recommended.

c. Electronic counter capable of reading at least 2 MHz. Systron-Donner Model 1037 recommended.

d. Distortion analyzer. Hewlett-Packard 332A recommended.

e. Variable autotransformer.

f. Fifty ohm, 5 watt termination. Tektronix 011 - 0099 - 00 recommended.

g. Two 50 ohm coaxial cables terminated with BNC connectors.

4.3.2 Power Supply Calibration

a. Connect the function generator to the autotransformer.

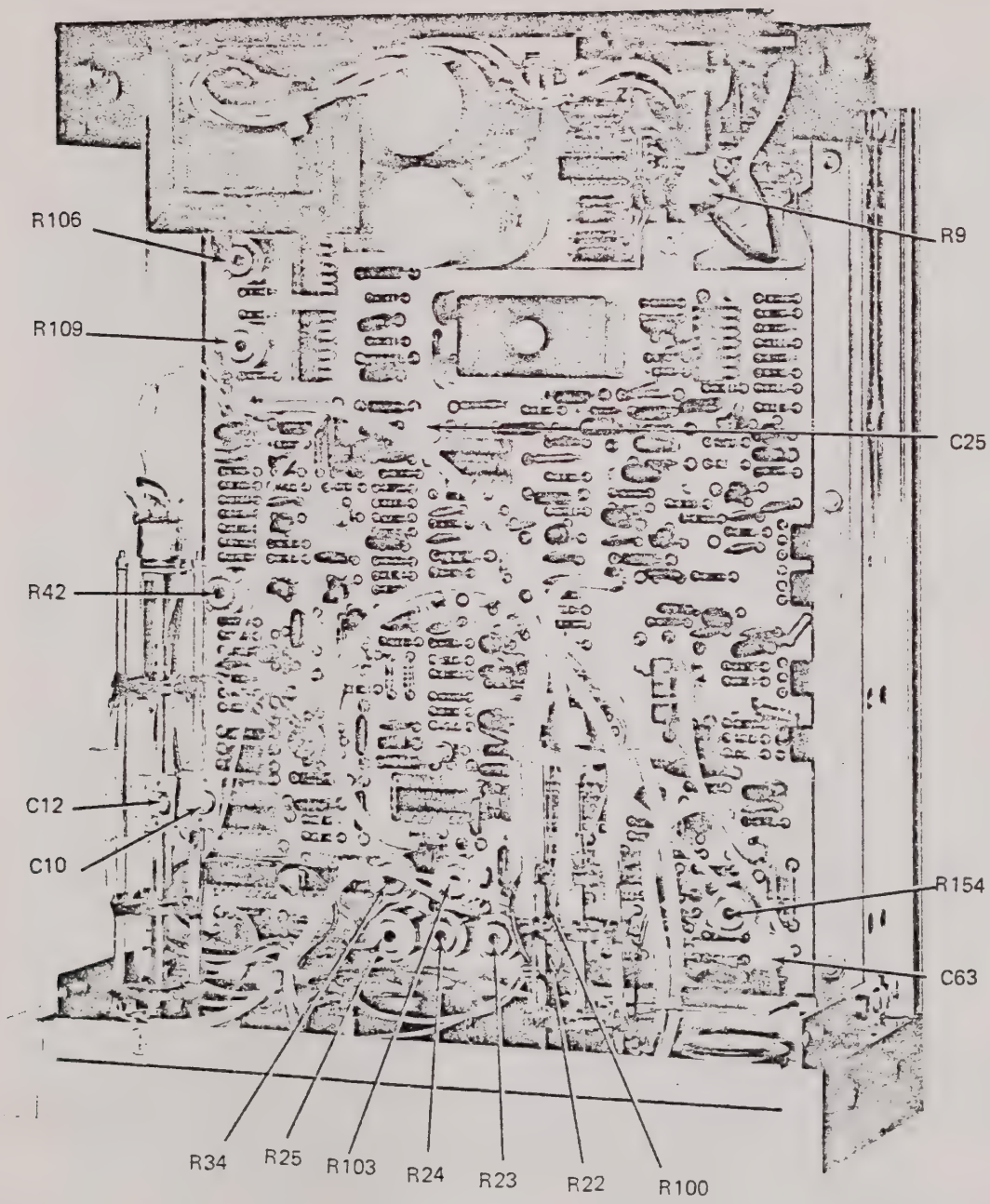


Figure 4-1. Top View — Model 401.

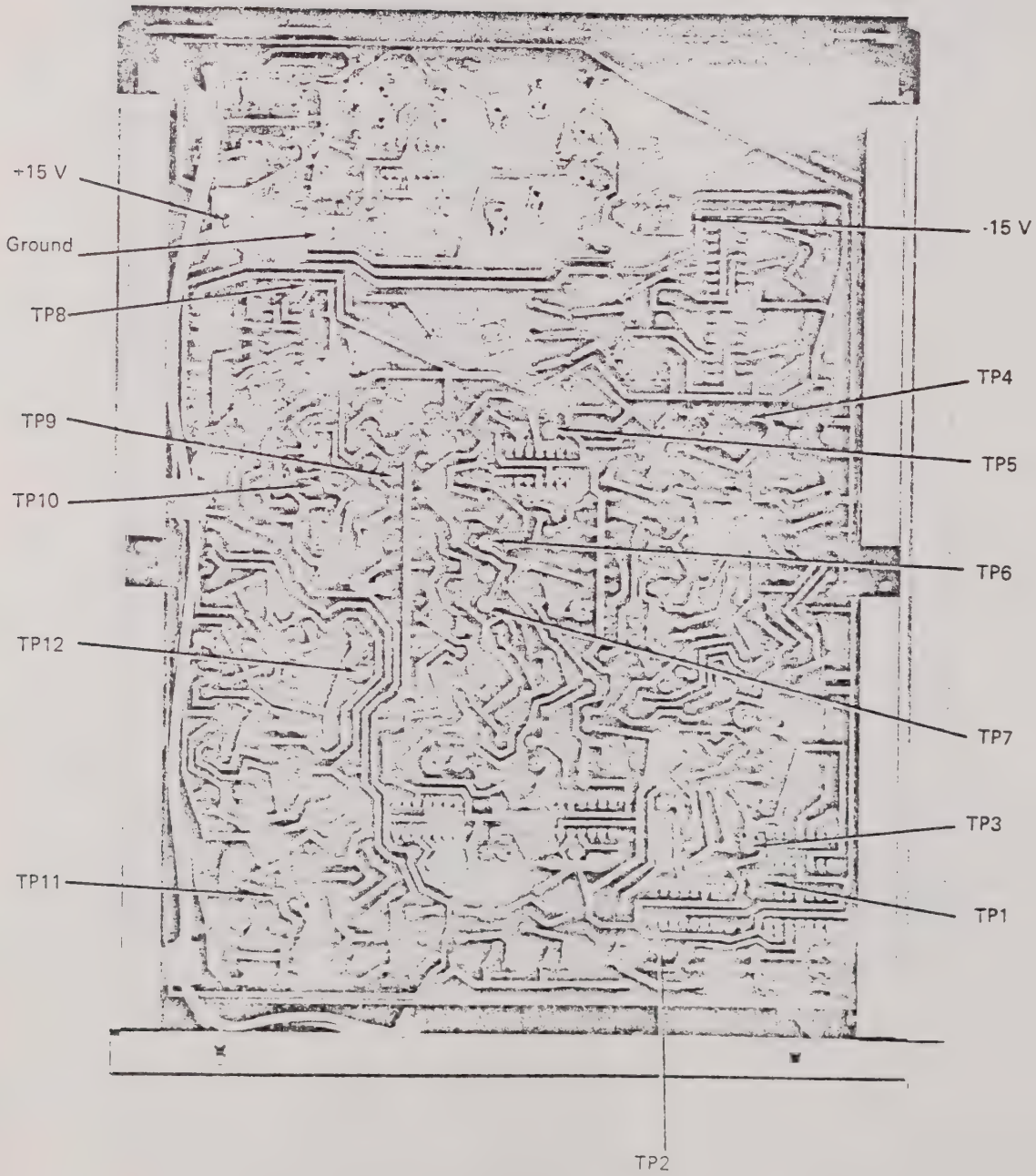


Figure 4-2. Bottom View – Model 401.

CAUTION

Verify that the slide switch on the back panel agrees with the line voltage prior to connecting the power cord.

b. Set the autotransformer for 115 or 230 volts.

c. Connect the digital voltmeter between the +15 volt test point and chassis ground. Adjust R9 for +15 ±0.05 volts.

d. Vary the line voltage +10%, then -10% and verify that the +15 volts does not change more than ±15 millivolts.

e. Connect the voltmeter between the -15 volt test point and chassis ground. Verify that the -15 volt supply is within ±2% of the +15 volt supply.

f. Vary the line voltage +10%, then -10% and verify that the -15 volts does not change more then ±15 millivolts.

g. Using the oscilloscope, check the ripple on the positive and negative power supplies. Vary the line voltage +10% and -10% while making the ripple check. Ripple should not exceed 15 millivolts peak-to-peak.

4.3.3 Square Wave and Symmetry Calibration

a. Set the function generator controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X1
VERNIER	CAL
Frequency Dial	0.1
WAVEFORM	sine (∿)
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
AMPLITUDE	fully clockwise
Impedance/Attenuator switch	50 OHMS/ 0 DB

b. Connect the 1 V PP⊔connector to the input of the digital voltmeter. Set the voltmeter to read dc voltage.

NOTE: Voltmeter indication will shift from +0.5 to -0.5 volts approximately every 5 seconds.

c. Adjust R100 for a positive peak of +0.5 volts ±1 mV, and R103 for a negative peak of -0.5 volts ±1 mV.

d. Set the FREQUENCY RANGE Hz selector to X10 K and the frequency dial to 1.

e. Disconnect the 1 V PP⊔connector from the voltmeter and connect it to the oscilloscope vertical and external trigger inputs. Set the oscilloscope for external triggering. Set the oscilloscope trigger slope to positive and the sweep rate to display exactly one cycle of square wave.

f. Set the oscilloscope sweep magnifier to X10 and position the square wave so that the negative-going edge is on the center graticule. Set the oscilloscope trigger slope to negative.

NOTE: Do not reposition the square wave with the oscilloscope controls.

g. Adjust R34, if necessary, to reposition the positive-going edge on the center graticule.

h. Switch the oscilloscope trigger slope from negative to positive several times and verify that both edges remain on the center graticule. If readjustment is necessary, always set the trigger slope to negative before adjusting R34.

4.3.4 Sine Wave Distortion Calibration

4.3.4.3 Method I

a. Set the function generator controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X10 K
VERNIER	CAL
Frequency Dial	2
WAVEFORM	sine (∿)
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
AMPLITUDE	fully clockwise
Impedance/Attenuator switch	50 OHMS/ 0 DB

b. Connect the OUTPUT connector to the distortion analyzer input. Terminate with 50 ohms at the distortion analyzer.

c. Adjust R106 and R109 for minimum distortion.

d. Set the frequency dial to 0.2 and adjust R42 for minimum distortion.

e. Return the frequency dial to 2 and verify that the distortion is less than 0.25%.

NOTE: After completion of the entire calibration procedure, recheck sine wave distortion. Readjust, if necessary.

4.3.4.2 Method II

a. Set the function generator controls as in step 4.1.4.1a, except set the frequency dial to 1.

b. Using a X1 probe, connect TP9 to the vertical input of the oscilloscope.

c. Adjust the frequency dial and VERNIER control for minimum signal amplitude on the oscilloscope.

NOTE: TP9 is the output of a notch filter that rejects only 10 kHz. Therefore, the oscilloscope display represents sine wave distortion.

d. First adjust R106 and R109 for minimum signal amplitude. Then adjust R42 for minimum signal amplitude.

4.3.5 Frequency Range and Dial Calibration

a. Set the function generator controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X10 K
VERNIER	CAL
Frequency Dial	0.2
WAVEFORM	square (⊓)
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)

Control	Setting
AMPLITUDE	fully clockwise
Impedance/Attenuator switch	50 OHMS/ 0 DB

b. Connect the OUTPUT connector to the input of the counter. Terminate with 50 ohms at the counter. Adjust the frequency dial for a reading of 2 kHz ±20 Hz. Loosen the Allen screw on the dial and position the dial to 0.2 then retighten the Allen screw.

NOTE: If the dial shaft has been idented by the Allen screw, burnish lightly with a fine file before attempting to align the dial.

c. Adjust R13 for 2 kHz ±2 Hz.

d. Set the frequency dial to 2 and adjust R22 for 20 kHz ±0.1%.

e. Return the frequency dial to 0.2 and verify a reading of 2 kHz ±1%. If the reading is out of tolerance, repeat steps (b) and (c) until both readings are in tolerance.

f. Set the frequency dial to the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Frequency
0.2	2 kHz ±20 Hz
0.5	5 kHz ±50 Hz
1	10 kHz ±100 Hz
1.6	16 kHz ±160 Hz
2	20 kHz ±200 Hz

g. Set the FREQUENCY RANGE Hz selector to X1 K and position the frequency dial to 2. Adjust R23 for a reading of 2 kHz ±2 Hz.

h. Set the frequency dial to the following positions and verify that the readings are within ±1%.

Dial Setting	Frequency
0.2	5 ms ±0.05 ms
0.5	500 Hz ±5 Hz
1	1 kHz ±10 Hz
1.6	1.6 kHz ±16 Hz
2	2 kHz ±20 Hz

i. Set the FREQUENCY RANGE Hz selector to X100 and position the frequency dial to 2. Adjust R24 for a 5 ms period ±0.005 ms.

j. Set the frequency dial to the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Frequency
0.2	50 ms ±0.5 ms
0.5	20 ms ±0.2 ms
1	10 ms ±0.1 ms
1.6	6.25 ms ±0.06 ms
2	5 ms ±0.05 ms

k. Set the FREQUENCY RANGE Hz selector to X10 and position the frequency dial to 2. Adjust R25 for a 50 ms period ±0.05 ms.

l. Set the frequency dial to the following positions and verify that the readings are within ±1%.

Dial Setting	Frequency
0.2	500 ms ±5 ms
0.5	200 ms ±2 ms
1	100 ms ±1 ms
1.6	62.5 ms ±0.62 ms
2	50 ms ±0.5 ms

m. Set the FREQUENCY RANGE Hz selector to X1 M and position the frequency dial to 0.2. Adjust C10 for a reading of 200 kHz ±4 kHz.

n. Position the frequency dial to 2 and adjust C25 for a reading of 2 MHz ±40 kHz.

o. Return the frequency dial to 2 and verify that the reading is still in tolerance. If not, repeat step (j) and (k) for a best case in tolerance reading.

p. Set the frequency dial to the following positions and verify that the readings are within ±2% of the dial setting.

Dial Setting	Frequency
0.2	200 kHz ±4 kHz
0.5	500 kHz ±10 kHz
1	1 MHz ±20 kHz
1.6	1.6 MHz ±32 kHz
2	2 MHz ±40 kHz

q. Set the FREQUENCY RANGE Hz selector to X100 K and position the frequency dial to 2. Adjust C12 for a reading of 200 kHz ±2 kHz.

r. Set the frequency dial to the following positions and verify that the readings are within ±1% of the dial setting.

Dial Setting	Frequency
0.2	20 kHz ±200 Hz
0.5	50 kHz ±500 Hz
1	100 kHz ±1 kHz
1.6	160 kHz ±1.6 kHz
2	200 kHz ±2 kHz

4.3.6 Output Amplifier Calibration

a. Set the function generator controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X10 K
VERNIER	CAL
Frequency Dial	1
WAVEFORM	sine (∿)
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
AMPLITUDE	fully clockwise
Impedance/Attenuator switch	50 OHMS/ 0 DB

b. Connect the OUTPUT connector to the input of the digital voltmeter. Do not terminate. Set the voltmeter to read ac voltage.

c. Adjust R154 for a sine wave amplitude of 7.42 volts rms (21 volts peak-to-peak).

d. Disconnect the OUTPUT connector from the voltmeter and connect it to the oscilloscope vertical input. Using the sine wave as a 21 volt peak-to-peak reference, verify that the amplitude of the other two waveforms are greater than 20 volts peak-to-peak.

e. Set the WAVEFORM switch to square (⊓) waveform. Terminate the OUTPUT with 50 ohms at the oscilloscope. Trigger the oscilloscope with the 1 V PP⊓output.

f. Set the FREQUENCY RANGE Hz switch to X1 M and position the frequency dial to 1.

g. Adjust trim capacitor C63 for the desired overshoot/rise time compensation.

h. Verify that rise time is less than 40 ns.

NOTE: Rise time may be adjusted to a higher value, if a smoother square wave is desired.

4.4 SPECIFICATION VERIFICATION

This section is designed to assist in comparing the instrument with its published specification.

4.4.1 Equipment (or equivalent) Required

The same equipment listed in paragraph 4.3.1 can be used in these checks.

4.4.2 Dial Accuracy Check

a. Connect the OUTPUT connector to the input of the counter. Set the WAVEFORM switch to square (⊓).

b. Set the instrument for the dial and range settings in Table 4 - 1 and verify the counter indications.

4.4.3 Sine Distortion Check

a. Connect the OUTPUT connector to the input of the distortion analyzer. Terminate with 50 ohms at the distortion analyzer.

b. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X10 K
Frequency Dial	1
VERNIER	CAL
Impedance/Attenuator switch	50 OHMS/ 0 DB
AMPLITUDE	fully clockwise
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
WAVEFORM	sine (∿)

c. Check several frequencies between 2 Hz and 20 kHz and verify that the distortion is less than 0.25%.

d. Check several frequencies between 20 kHz and 200 kHz and verify that the distortion is less than 0.5%.

e. Check several frequencies between 200 kHz and 600 kHz (distortion analyzer limit) and verify that the distortion is less than 3%.

4.4.4 Symmetry Check

4.4.4.1 Method I

a. Connect the OUTPUT connector through a tee to the A and B inputs of the counter. Set the counter to TIME B—A.

b. Set the FREQUENCY RANGE Hz switch to 1 K, the frequency dial to 1 and the WAVEFORM switch to square (⊓).

Table 4-1. Dial Accuracy Check.

Dial	Range	Counter Indication
0.2	X1	4.90 s to 5.10 s
1	X1	980 ms to 1.02 s
2	X1	490 ms to 520 ms
0.2	X10	495 ms to 505 ms
1	X10	99 ms to 101 ms
2	X10	49.5 ms to 50.5 ms
0.2	X100	49.5 ms to 50.5 ms
1	X100	9.9 ms to 10.1 ms
2	X100	4.95 ms to 5.05 ms
0.2	X1 K	4.95 ms to 5.05 ms
1	X1 K	990 Hz to 1010 Hz
2	X1 K	1980 Hz to 2020 Hz
0.2	X10 K	1980 Hz to 2020 Hz
1	X10 K	9.90 kHz to 10.10 kHz
2	X10 K	19.80 kHz to 20.20 kHz
0.2	X100 K	19.80 kHz to 20.20 kHz
1	X100 K	99.90 kHz to 101.0 kHz
2	X100 K	198.0 kHz to 202.0 kHz
0.2	X1 M	196.0 kHz to 204 kHz
1	X1 M	980.0 kHz to 1.02 MHz
2	X1 M	1.96 MHz to 2.04 MHz

c. Adjust the counter trigger level to input A for positive triggering and set the trigger level to input B for negative triggering. Record the counter indication.

d. Adjust the trigger level to input A for negative triggering and trigger level to input B for positive triggering. (Set trigger levels equal.) Record the counter indication.

e. Verify that the two counter indications are within 0.5% of each other.

f. Check several frequencies up to 200 kHz and verify that the time symmetry is >99.5%.

g. Check several frequencies between 200 kHz and 2 MHz and verify that the time symmetry is >98%.

4.4.4.2 Method II

a. Connect the OUTPUT to the input of the oscilloscope. Terminate with 50 ohms at the oscilloscope.

b. Set the FREQUENCY RANGE Hz switch to X1 K, the frequency dial to 1 and the WAVEFORM switch to square (⊓).

c. Select the delayed sweep on the oscilloscope. Using the delayed sweep multiplier, determine the width, the positive and negative halves of the waveform. Verify that the two halves are within 0.5% of each other.

d. Check several frequencies up to 200 kHz and verify that the time symmetry is >99.5%.

e. Check several frequencies between 200 kHz and 2 MHz and verify that the time symmetry is >98%.

4.4.5 Frequency Response Check

a. Set the distortion analyzer to the voltmeter function (or use an rms reading voltmeter with a dB scale). Connect the OUTPUT connector to the distortion analyzer input. Terminate with 50 ohms at the input of the distortion analyzer.

b. Set the FREQUENCY RANGE Hz switch to X1 K, the frequency dial to 1 and the WAVEFORM switch to sine (∿).

c. Adjust the AMPLITUDE control for 0 dB on the highest possible scale.

d. Vary the frequency from 10 Hz to 200 kHz and verify that the amplitude does not change more than ±0.4 dB (1%).

e. Vary the frequency from 200 kHz to 2 MHz and verify that the amplitude does not change more than ±1.2 dB (3%).

NOTE: Voltmeter tolerances must be taken into account.

4.4.6 Square Wave Response Check

a. Connect the OUTPUT connector to the input of the oscilloscope. Terminate with 50 ohms at the oscilloscope.

b. Set the FREQUENCY RANGE Hz switch to X1 K, the frequency dial to 1 and the WAVEFORM switch to square (⊓).

c. Verify that the rise and fall times of the square wave (between the 10% and 90% point) are less than 40 ns.

d. Make the rise and fall time check at several other frequencies and verify that the rise and fall times are less than 40 ns.

e. Verify that aberrations are less than 5% of the peak-to-peak value of the square wave.

4.4.7 Output Check

a. Set the distortion analyzer to the voltmeter function. Connect the OUTPUT connector to the input of the distortion analyzer. Terminate with 50 ohms at the distortion analyzer input.

b. Set the FREQUENCY RANGE Hz switch and the frequency dial to any position and the WAVEFORM switch to sine (∿). Set the AMPLITUDE control fully clockwise. Verify an amplitude of 3.5 V rms and record the dB reading.

c. Set the AMPLITUDE control fully counterclockwise and verify that the voltmeter reading decreases more than 80 dB.

4.4.8 External Frequency Control Check

a. Set the instrument controls as follows:

Control	Setting
FREQUENCY RANGE Hz switch	X1 K
VERNIER	fully counterclockwise
WAVEFORM	square (⊓⊔)
OFFSET switch	NAR
OFFSET control	0 volts offset (mid-range)
Impedance/Attenuator switch	50 OHMS/ 0 DB
AMPLITUDE	fully clockwise

b. Connect the OUTPUT connector to the input of the counter.

c. Connect the low voltage dc source set for 0 volts to the FM INPUT.

d. Set the frequency dial to 0.1 and record the counter indication.

e. Set the low voltage dc source to +5 volts and verify that the frequency increases by at least a factor of 1000.

4.5 TROUBLESHOOTING

Before assuming that the instrument has a malfunction, double check the control settings and power connections. Verify also that the instrument has been properly calibrated. An uncalibrated instrument often may exhibit some of the same symptoms as one that is malfunctioning.

4.5.1 Disassembly Instructions

To gain access to the circuit components and printed circuit board, remove the four flat-head screws (2 in each cover) from the top and bottom covers and slide the covers off. In most situations, it is not necessary to remove the side covers and rails. However, if the need arises, the side covers may be removed by removing the two flat-head screws from the rear end blocks and sliding the side covers off. To remove the side rails, remove the two flat-head screws from the front end blocks, then remove the round head screws (one at each end of the rails) from the upper and lower rails.

4.5.2 General Troubleshooting Instructions

Since the circuitry that generates the triangle and square waveforms is a closed loop (integrator, comparator and squaring circuit), it is often difficult to determine just where the malfunction exsists. The function of this paragraph is to set down some general troubleshooting guidelines that will help to localize the malfunction. Usually when the closed loop has a malfunction, no waveforms are present at the output and the output is offset to a dc level of + or -15 volts. If these conditions exsists, perform the following steps:

a. Set the FREQUENCY RANGE Hz switch to X10 K and the frequency dial to 2. Verify the voltage at TP2 is approximately -10 V and approximately +10 V at TP3. If the voltages are present, go to step (b), if not, troubleshoot the frequency control circuit (Z3, Z4, Z6 and associated circuitry).

b. Check the voltage at the input (pin 11 of Z5) and the output (the junction of R63 and R64) of the integrator. If the

input voltage (approximately + or -1.7 V) and the output voltage (approximately + or -10 V) are opposite polarity, go to step (c). If the input and output are the same polarity or opposite polarity with the output reduced in amplitude (< 5 V), the fault is in the integrator (Q5A through Q13).

c. Monitor TP8 with an oscilloscope. Measure check the voltage between pin 4 of Z7 and ground with a digital voltmeter and note the polarity. Using a low voltage dc source, apply approximately 1 V dc (the same polarity as noted above) between pin 3 and ground. If the voltage at TP8 shifts levels (positive to negative, or negative to positive), go to step (d); if not, troubleshoot the comparator (Z7 and associated circuitry).

d. If the instrument passes steps (a), (b) and (c), troubleshoot the squaring circuit. For specific problems and their problems and their probable causes, see Table 4-2.

Table 4-2. Troubleshooting.

Sympton	Probable Cause	Check
1. No output and pilot lamp does not illuminate.	1. No input power, or power supply malfunction.	1. Check line cord connection, fuse and line voltage. If all are correct, troubleshoot the power supply.
2. Pilot lamp illuminated but no waveforms present at output and baseline is at 0 volts.	2. No input from waveform switch or output amplifier is inoperative.	2. Check for waveform at TP11. If waveform is not present, troubleshoot the waveform switch. If waveform is present, troubleshoot the output amplifier.
3. No waveforms present at output and baseline is + or -15 volts dc.	3. Closed loop consisting of integrator, comparator and squaring circuit.	3. Check the voltage at the input (pin 11 of Z5) and the output (junction of R63 and R64) of the integrator. If the input (+ or -1.7 V) and the output (+ or -10 V) are the same polarity, the integrator is malfunctioning. If the input and output voltages are opposite polarity, but the amplitude at the output is < than 5 volts, check integrator output transistors Q12 and Q13 and their associated circuitry. For all other cases of integrator input and output voltages, the comparator and/or the squaring circuits are faulty.
4. Sawtooth output in the triangle (∿) position. Very narrow pulses in the square wave (⊓) position.	4. Positive or negative frequency control voltage missing.	4. Check TP2 and TP3 for proper voltage. Check diode bridge network for open diode.

Symptom	Probable Cause	Check
5. All frequency ranges reading high.	5. Open feedback loop to Z6.	5. Check for open diode across terminals 7 and 8 of Z5.
6. Positive and negative peaks of all waveforms unequal and all waveforms unsymmetrical.	6. Z8 or Z9 malfunctioning.	6. Check the supply voltages to Z8 and Z9. If voltages are correct, replace Z8 or Z9.
7. Triangle and square wave output present at the output but sine wave is missing.	7. Sine converter or sine amplifier inoperative.	7. Check for correct voltages (approximately 3 volts) at pin 10 or Z10 and Z11. Check the sine shaper output at TP8. If sine wave is not present, replace the sine shaper. If sine wave is present, troubleshoot the sine amplifier.
8. Sine wave output distorted.	8. Sine shaper, sine amplifier or output amplifier faulty.	8. Check distortion at TP8. If distortion is > 0.18%, replace the sine shaper. If not, check the distortion at the output of the sine amplifier. If distortion is >0.25%, troubleshoot the sine amplifier; if not, troubleshoot the output amplifier.
9. Sine wave amplitude low but triangle and square waveform amplitude correct.	9. Sine converter or sine amplifier faulty.	9. Check pin 10 of Z10 and Z11 for +3 and -3 volts respectively. Check for a 6 volt sine wave at TP8. If voltage readings are correct, troubleshoot sine amplifier.
10. Amplitudes of all waveforms low.	10. Output amplifier faulty, or square wave input to comparator low.	10. Check waveform amplitudes at the input of output amplifier. If amplitudes are 10 V p—p, troubleshoot the output amplifier; if not, troubleshoot the squaring circuit.

SECTION V

THEORY OF OPERATION

5.1 GENERAL DESCRIPTION

Refer to Block Diagram 41000 - 222 for the following explanation. Bridge diode numbers have been assigned to facilitate the discussion.

Frequency dial, potentiometer R14, establishes the level of frequency control voltage at the outputs of amplifiers Z4 and Z6. These two control voltages determine the currents that flow through resistors R29 and R37. These currents charge and discharge the integrating capacitor. The amount of charging current and the size of the integrating capacitor selected by the range selector determine the output frequency of the function generator.

The triangle and square waveforms are simultaneously developed in the function generator. The linear charging and discharging of the integrating capacitor develops the triangle waveform which is level-detected by the comparator to develop the square waveform. The comparator output is connected to the junction of bridge diodes CR3 and CR4 and this alternating step voltage is used to steer the charging current to the integrating capacitor.

When the comparator output is negative, CR4 is forward biased and the current through R29 is diverted from the integrating capacitor. Diode CR3 is then reverse biased and the integrating capacitor charges negatively through R37, causing the voltage at the output of the integrator to go positive at a constant rate. When the voltage reaches the upper hysteresis point of the comparator, the state of the comparator changes, making the junction of CR3 and CR4 positive. CR4 is then reverse biased and CR3 forward biased. The current through R29 charges the integrating capacitor positively, causing the voltage at the output of the integrator to go negative at a constant rate. When the voltage reaches the lower hysteresis point of the comparator, the state of the comparator changes, making the junction of CR3 and CR4 negative. The time required to charge and discharge the integrating capacitor determine the period of one cycle and therefore the frequency.

The output of the comparator is also applied to the squaring circuit which utilizes complementary differential pairs and stable positive and negative voltage sources to produce an amplified, symmetrical square waveform. A signal of equal amplitude and a 180 degree phase shift from the square wave output is coupled back to the inverting input of the comparator to establish its hysteresis points.

The sine wave is produced by shaping the triangle wave, which results in a sine wave of reduced amplitude. A non-inverting amplifier restores the amplitude of the sine wave to that of the applied triangle. An output amplifier provides final amplification for all three waveforms.

Applying a voltage to the FM input adds voltage to the summing junction of amplifier Z1 in the frequency control section. This additional voltage changes the charging rate of the integrating capacitor which varies the output frequency of the function generator.

5.2 CIRCUIT DESCRIPTION

Refer to Schematic 40000 - 410 and 40000 - 395 for the following circuit descriptions.

5.2.1 Frequency Control

The frequency control circuit consists of amplifiers Z3, Z4 and Z6 and diode bridge network Z5. The voltages from the frequency dial potentiometer, R14, frequency vernier R15 and/or the FM input are summed at the input of amplifier Z3. With no voltage applied to the FM input, amplifier Z3 has a gain of approximately 0.7. Therefore when R14 is at the maximum counterclockwise position, the output of Z3 is approximately -10 volts. Diodes CR8 and CR9 provide input over-voltage protection. Potentiometers R22 through R25 are fine gain adjustments for amplifier Z3 and the X10 through X10 k frequency ranges. The output of Z3 is coupled to the inverting input of Z6 whose output supplies the positive frequency control voltage. The output of Z6 is also fed to the inverting input of Z4 whose output supplies the negative frequency control voltage. Top symmetry adjust R34, adjusts the gain of Z4 to be equal to that of Z6. The gain of both amplifiers is approximately 1.

The level of the positive and negative frequency control voltages and resistors R29 and R37 determine the magnitude of the currents that charge and discharge the integrating capacitor (C10 through C17).

The currents are alternately switched to the integrator by the alternating step voltage at terminals 5 and 11 of Z5. When the step voltage is positive, the diode across terminals 11 and 12 is reverse biased and the integrating capacitor charges positively. When the step voltage is negative, the diode across terminals 5 and 6 is reverse biased and the integrating capacitor charges negatively. Diode CR10 and CR11 establish a threshold point to prevent the bridge diodes from being switched on by spurious signals.

5.2.2 Integrator

The integrator consists of an integrating amplifier and an integrating capacitor (C10 through C17). The integrating amplifier is actually two separate amplifiers, one a dc amplifier which is active at the lower frequencies and the other, an ac amplifier which takes over at the higher frequencies. Dual FET, Q5A/B, is the input for the dc amplifier and differential amplifier Q5/Q8 is the input for the ac section. The RC network consisting of C6 and R43, determines the frequency where the shift from the dc to the ac amplifier occurs. Capacitors C8 and C16 are roll-off capacitors and potentiometer R42 is the integrator balance which adjusts the symmetry of the waveform at the low end of the frequency dial.

The integrating amplifier is basically a high gain amplifier which draws practically no input current. The summing point (the point between R39 and C6) is held at approximately 0 volts through the feedback loop provided by the integrating capacitor (C10 through C17). The amount of current flowing out of, or into the integrating amplifier output is determined by the level of the frequency control voltage. These currents in the feedback loop develops the triangle wave.

5.2.3 Comparator

The comparator is essentially a level-detector. The inputs to the comparator are the integrator output (triangle) and the 180^{o} square wave output (see paragraph 5.2.4). This 10 V p—p square wave divided by resistors R72 and R77, establishes the hysteresis points of the comparator and therefore limits the triangle amplitude.

The comparator output is an alternating step voltage of approximately 3.4 volts peak-to-peak (-0.35 to +3.05). The baseline of the step voltage is shifted down approximately 1.2 volts by the junction of transistor Q14 and diode CR15. Therefore, at the cathode of CR15, the voltage swings from -1.6 to +1.6 volts.

Resistors R69,71 and R72,77 constitute voltage dividers which limit the input voltages to the comparator. Capacitors C25 and C26 compensate for

the comparator switching time at high frequencies, thus insuring a constant triangle amplitude over the entire frequency range. Emitter follower, Q14, is used for impedance matching.

5.2.4 Squaring Circuit

The squaring circuit has two 10 volt peak-to-peak outputs. One output is in phase with the input and the other is 180° out of phase. The 180° output is coupled back to the inverting input of the comparator and the in-phase output is fed to the waveform switch.

The squaring circuit consists of two complementary differential pairs, Q17/Q19 and Q18/-Q20 which drive complementary output pairs Q15/-Q16 and Q21/Q22. The alternating step voltage (comparator output) at the bases of Q17 and Q19 simultaneously turns one transistor on and the other off. Assuming that the step voltage is positive, Q17 is on and Q18 is off, consequently Q19 is off and Q20 is on. The conduction of Q17 and Q20 turn Q16 and Q21 on, causing the collector of Q16 to swing to -5 volts and the collector of Q21 to swing to +5 volts. When the voltage at the bases of Q17 and Q18 is negative, the conducting and non-conducting states of the transistors are reversed and the collector of Q15 swings to +5 volts, while the collector of Q22 swings to -5 volts.

Clamp diodes CR15 through CR18 provide overvoltage protection for the bases of output transistors Q15, Q16, Q21 and Q22. Capacitors C35 and C37 are bypass capacitors and C36 is a roll-off capacitor. Operational amplifiers Z8 and Z9 provide stable positive and negative 5 volt sources for the output transistors. Potentiometers R100 and R103 are gain adjustments for the amplifiers. Resistors R94 and R95 divide the 10 volt peak-to-peak square wave to develop the 1 volt peak-to-peak square wave output.

5.2.5 Sine Converter

The sine converter shapes the 10 volt peak-to-peak triangle into a 6 volt peak-to-peak sine wave. Operational amplifiers Z10 and Z11, configured as voltage sources for the sine shapers. Potentiometers R106 and R109 are gain adjustments for amplifiers Z10 and Z11.

5.2.6 Sine Amplifier

The sine amplifier has a gain of approximately 1.67, therefore the 6 volt sine wave from the sine converter is amplified to 10 volts peak-to-peak. The sine amplifier consisting of Z12 and transistors Q23 through Q26 has a differential input and a push-pull output. Diodes CR20 and CR21 establish the bias for output transistor Q25 and Q26 and resistors R131 and R132 are feedback resistors for amplifier gain control. Capacitors C51, C52 and resistors R132, R136 and R137 comprise a 10 kHz notch filter which is used for sine distortion calibration.

5.2.7 Output Amplifier

The output amplifier which has a gain of 2, provides final amplification for all three waveforms. The waveform switch connects one of the three waveforms to the input of the amplifier through amplitude control R128. Offset voltage is applied at the summing point by offset control R144. The input stage of the output amplifier consists of complementary differential pairs, Q27/Q29 and Q28/Q30. These complementary differential pairs drive push-pull power amplifiers Q31 and Q32 which, in turn, drive output emitter-followers Q33 and Q34. Feedback is taken through the RC network consisting of R148, R149, R150, R151 and C60, C61 and trim capacitor C63. Potentiometer R154 is the amplifier gain adjust. Diodes CR22 and CR23 establish the bias for transistors Q33 and Q34.

5.2.8 Power Supply

The power supply is comprised of a +15 volt and -15 volt regulators. The two regulators are identical with the exception that the -15 volt regulator is referenced by resistor R510, while the +15 volt regulator is referenced by zener diode CR508. The operation of the two regulators are the same, therefore only the positive regulator will be discussed.

The reference for the regulator is established by zener diode CR508 and R512 is adjusted so that the voltages at terminals 4 and 5 of amplifier Z501 are equal. Any error sensed at the regulator output will cause the voltage at terminal 5 and hence at terminal 10 to increase or decrease, depending on what has happened at the output. The error voltage at terminal 10 causes the current through series pass transistor Q503 to increase if the regulator output has decreased or decrease if the regulator output has increased. Transistor Q501 provides over-current protection for the regulator. When an over-current condition occurs, Q501 is forward biased by the voltage drop across R502, thus the excess current is shunted through Q501. When the over-current is removed, the power supply is restored to normal operation.

SECTION VI

PARTS LIST

6.1 ABBREVIATIONS AND SYMBOLS

6.1.1 Reference Designations

Reference designations in the following parts list correspond to the circuit symbols used in the following schematics:

Drawing No. 40000-410
Drawing No. 40000-395

6.1.2 Abbreviations

ampere	A
capacitor	C
diode	CR
fuse	F
indicator lamp	DS
jack	J
kilohm	K
megohm	M
microfarad	μF
peak inverse voltage	PIV
resistor	R
switch	S
transformer	T
transistor	Q
variable	VAR
volts	V
watts	W
integrated circuit	IC

6.1.3 Manufacturers

Allen Bradley Company	AB
ACDC Electronics	ACDC
American Components Incorporated	ACI
American Radionics Incorporated	Amer. Rad.
Amphenol RF Division	Amphenol
Arco Electronics Incorporated	Arco
Buckeye Stamping Company	Buckeye
Bussman Manufacturing Company	Buss
Continental Wirt	CW
Corning Glass Works	Corning
Datapulse Division of Systron-Donner Corporation	DP
Duncan Electronics Incorporated	Duncan
Electro Motive Manufacturing Company	Elmenco
Erie Technological Products Incorporated	Erie
Fairchild Semiconductor Products Incorporated	FT
Motorola Semiconductor Products Incorporated	Mot.
Pacific Electricord Company	Electricord
Radio Corporation of America	RCA
Sangamo Electric Company	Sangamo
Siliconix Incorporated	Siliconix
Sprague Electric Company	Sprague
STM Corporation	STM
Sylvania Electric Products Incorporated	Syl.
Texas Instruments	TI
Inter-Market Incorporated	IM

6.2 FRONT PANEL ASSEMBLY

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
J1	15050-000	3	Connector, BNC	Amphenol	667-231-221
J2			Same as J1		
J3			Same as J1		
R11	10010-100	1	10 ohm, ¼ W, 5%	AB	CB1005
R14	10344-102	1	1 k, Var.	Duncan	1630
R128	20043-501	1	500 ohm, Var.	AB	JA1N056S501AA
R129	10011-209	1	2 ohm, ½ W, 5%	AB	EB2095
R152	10010-154	1	150 k, ¼ W, 5%	AB	CB1545
R174	10750-551	1	550 ohm, ¼ W, 1%		RN60D
R175	10710-502	1	4.99 k, ¼ W, 1%		RN60D
R176	10710-499	1	49.9 ohm, ¼ W, 1%		RN60D
S5	15310-002	1	Switch, Slide	CW	G124
S6	15310-001	1	Switch, Slide	CW	G128S
DS501	15450-044	1	Indicator Light	IM	BFA14GRN
	15400-037	2	Knob	Buckeye	70CL2
	15400-035 10684	2	Knob	Buckeye	PS70D2
	15400-034 10685	1	Knob	Buckeye	PS50-2
	B33000-250	1	Dial	Buckeye	

6.3 BACK PANEL ASSEMBLY

F501	15470-036	1	Fuse, ¼A slo-blow, 250 V	Buss	MDL¼
Q503	12616-000	1	PNP, 2N4918	Mot.	2N4918
Q504	12666-000	1	NPN, 2N4921	Mot.	2N4921
S502	15310-003	1	Switch, Slide, 115/230 V	CW	G626 Modif.
T501	C24010-013	1	Transformer, Power	ACDC	30497
	15470-022	1	Fuseholder	Buss	HKP
	17130-006	1	Line Cord (Power)	Electricord	C2112-008BL

6.4 FREQUENCY RANGE SWITCH ASSEMBLY

C10	11313-200	1	1.5–20 pF, Mica, Var.	Arco	402
C11	11017-330	1	33 pF, 5%	Sangamo	RR1433
C12	11313-350	1	3–35 pF, Mica, Var.	Arco	403
C13	11005-471	1	470 pF, 1%	Sangamo	RR06347F
				Elmenco	CM15E471F
C14	11224-502	1	0.005 μF, 2%	Amer. Rad.	MPW2502G
C15	11224-503	1	0.05 μF, 2%	Amer. Rad.	MPW2503G
C16	11224-504	1	0.5 μF, 2%	Amer. Rad.	MPW2504G
C17	11214-505	1	5 μF, 5%	Amer. Rad.	MPW2505J
R10	10750-903	2	90 k, ¼ W, 1%		CR¼RN60D

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R15	10091-103	1	10 k, 20%, ½ W	AB	WA4N056S103MA
R32			Same as R10		
S3	A25250-048	1	Switch, Frequency Range	DP	
	C32001-241	1	Bracket, Frequency Range	DP	
	A32001-242	1	Coupling	DP	
6.5	WAVEFORM SWITCH ASSEMBLY				
R125	10010-331	3	330 ohm, 5%, ¼ W	AB	CB3315
R126			Same as R125		
R127			Same as R125		
R144	10091-103	1	10 k, ±20%, ½ W, Var.	AB	WA4N056S103MA
S4	A25260-019	1	Switch, Waveform Select	DP	
	A32001-242	1	Coupling	DP	
	B33000-262	1	Support, Coax Cable	DP	
6.6	PRINTED CIRCUIT BOARD ASSEMBLY				
C5	11241-223	31	0.022 μF, 25 V	Sprague	HY525
C6	11073-102	4	1000 pF, 100 V, 5%	Arco	DM15E102J
C7	11077-680	1	68 pF, 500 V, 5%	Arco	DM15E680J
C8	11077-681	1	680 pF, 100 V, 1%	Arco	DM15F681J
C9			Same as C5		
C18			Same as C5		
C19			Same as C5		
C20	11491-475	6	4.7 μF, 20 V, 20%	Comp. Inc.	TD1-020-475-20
C21			Same as C20		
C22			Same as C5		
C23			Same as C5		
C24	11077-220	3	22 pF, 500 V, 5%	Arco	DM15E220J
C25	11309-600	1	15–60 pF	Erie	S38-011F-15-60
C26	11077-470	3	47 pF, 500 V, 5%	Arco	DM15E470J
C27			Same as C5		
C28			Same as C5		
C29	11077-100	2	10 pF, 500 V, 5%	Arco	DM15E100J
C30			Same as C5		
C31			Same as C5		
C32			Same as C5		
C33			Same as C5		
C34			Same as C5		
C35			Same as C6		
C36	11077-330	1	33 pF, 500 V, 5%	Arco	DM15E330J
C37			Same as C6		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C38			Same as C5		
C39			Same as C5		
C40			Same as C20		
C41			Same as C20		
C42			Same as C29		
C43			Same as C5		
C44			Same as C5		
C45			Same as C20		
C46			Same as C20		
C47			Same as C5		
C48			Same as C5		
C49			Same as C6		
C51	11079-501	2	500 pF, 500 V, 1%	Arco	DM15-501F
C52			Same as C51		
C53			Same as C24		
C54			Same as C26		
C55	11079-102	1	1000 pF, 100 V, 1%	Arco	DM15-102F
C56			Same as C5		
C58			Same as C26		
C59			Same as C5		
C60	11077-150	1	15 pF, 500 V, 5%	Arco	DM15-150J
C61			Same as C24		
C62			Same as C5		
C63	11305-250	1	7–25 pF, 350 V	Erie	538-014-93R
C64			Same as C5		
C65			Same as C5		
C66	11247-203	1	0.02 μF, 500 V	Erie	841000Z5VO203Z
C67	11267-255	1	2.2 pF	Erie	301-000-COJ0229C
C68			Same as C5		
C69			Same as C5		
C70	11491-226	7	22 μF, 20 V	Sprague	19692280020FB
C71			Same as C70		
C72			Same as C70		
C73			Same as C5		
C74			Same as C70		
C75			Same as C70		
C76			Same as C5		
C77			Same as C5		
C78			Same as C5		
C79			Same as C5		
C80	11077-509	1	5 pF, 500 V, 5%	Arco	DM10-050K
C501	11161-358	2	3500 μF, 25 V	STM	23C25TA352
C502			Same as C501		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
C503			Same as C70		
C504			Same as C70		
Q5 A & B	12715-000	1	NPN, 2N3958	Siliconix	U235/2N3958
Q6	12605-018	11	PNP, MPS6519	Mot.	MPS6519
Q7			Same as Q6		
Q8			Same as Q6		
Q9	12645-013	2	NPN, 2N5179	RCA	2N5179
Q10			Same as Q6		
Q11			Same as Q9		
Q12	12645-016	5	MPS6515	Mot.	MPS6515
Q13			Same as Q6		
Q14	22635-003	5	NPN, DP633		2N2369A
Q15	12605-012	4	PNP, 2N4258	Mot.	2N4258
Q16			Same as Q14		
Q17			Same as Q14		
Q18			Same as Q15		
Q19			Same as Q14		
Q20			Same as Q15		
Q21			Same as Q15		
Q22			Same as Q14		
Q23			Same as Q6		
Q24			Same as Q6		
Q25			Same as Q12		
Q26			Same as Q6		
Q27			Same as Q12		
Q28			Same as Q6		
Q29			Same as Q12		
Q30			Same as Q6		
Q31	12605-017	2	PNP, MPSU52	Mot.	MPSU52
Q32	12645-017	2	MPSU02	Mot.	MPSU02
Q33			Same as Q32		
Q34			Same as Q31		
Q501			Same as Q6		
Q502			Same as Q12		
R12	10010-275	2	2.7 M, ¼ W, 5%	AB	CB2755
R13	10439-103	1	10 k, ½ W, 10%	AB	SV1031
R16	10750-273	1	27.4 k, ¼ W, 1%	TI	CR¼, RN60D
R17			Same as R12		
R18	10710-103	7	10 k, ¼ W, 1%	Corning	NA60
R19	10750-153	1	15 k, ¼ W, 1%	TI	CR¼, RN60D
R20	10010-123	1	12 k, ¼ W, 5%	AB	CB1235
R21	10750-452	1	4.53 k, ¼ W, 1%	TI	CR¼, RN60D
R22	10439-202	10	2 k, ½ W, 10%, Var.	AB	SV2021

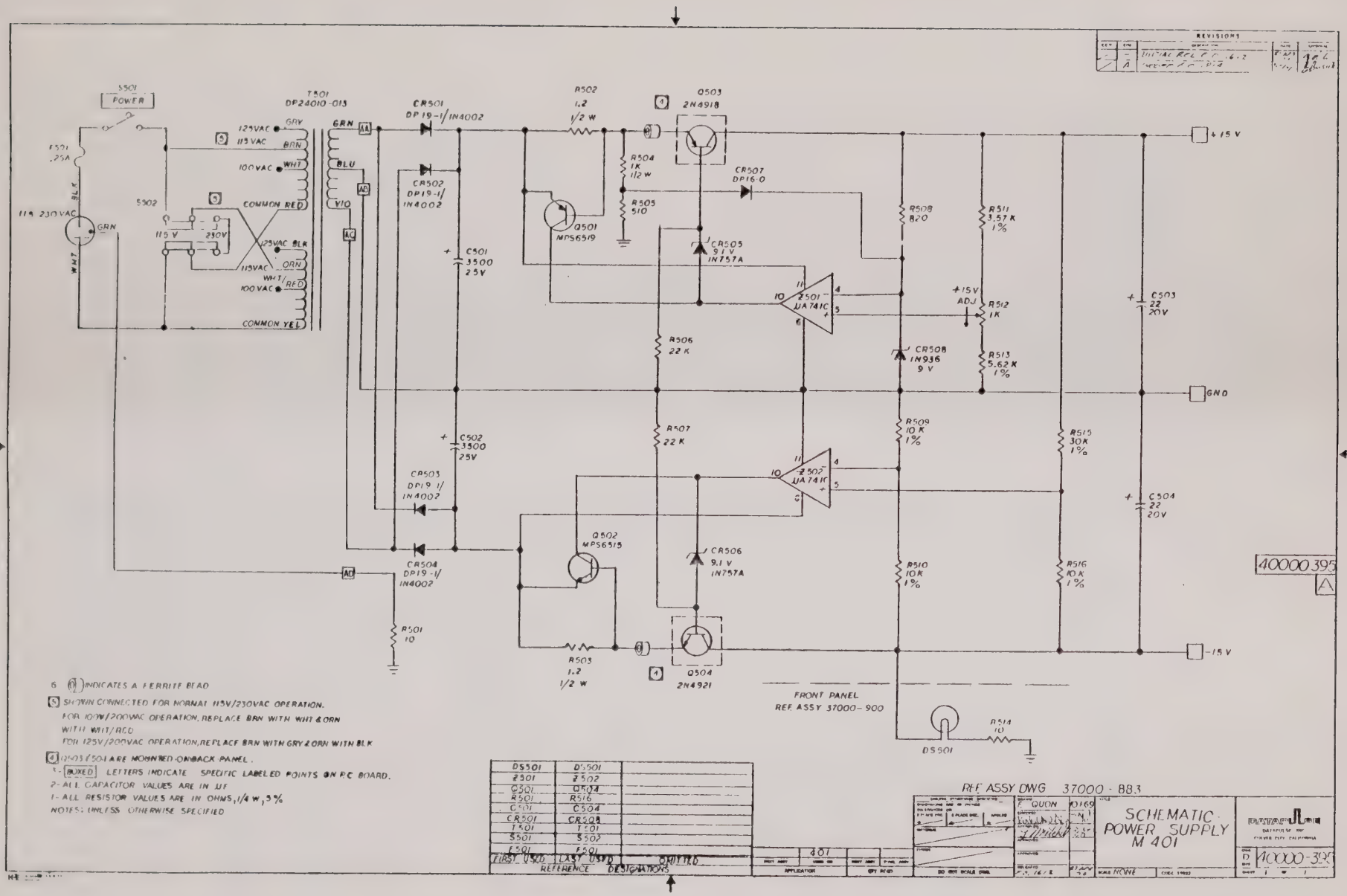
REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R23			Same as R22		
R24			Same as R22		
R25	10437-103	2	10 k, ¼ W, 20%, Var.	AB	FR103M
R26			Same as R18		
R27	10010-512	1	5.1 k, ¼ W, 5%	AB	CB5125
R28	10781-502	1	4.99 k, 1/8 W, 0.1%	ACI	EE-1/8, RN60C
R29	10710-502	5	4.99 k, ¼ W, 1%	Corning	NA60
R30	10010-103	2	10 k, ¼ W, 5%	AB	CB1035
R31	10750-952	1	9.53 k, ¼ W, 1%	TI	CR¼, RN60D
R33			Same as R29		
R34	10437-102	5	1 k, ¼ W, 20%, Var.	AB	FR102M
R35	10010-472	4	4.7 k, ¼ W, 5%	AB	CB2425
R36	10010-100	9	10 ohm, ¼ W, 5%	AB	CB1005
R37			Same as R29		
R38			Same as R30		
R39	10010-104	2	100 k, ¼ W, 5%	AB	CB1045
R40	10010-203	2	20 k, ¼ W, 5%	AB	CB2035
R41	10010-303	2	30 k, ¼ W, 5%	AB	CB3035
R42			Same as R25		
R43	10010-393	1	39 k, ¼ W, 5%	AB	CB3395
R44	10010-182	2	1.8 k, ¼ W, 5%	AB	CB1825
R45			Same as R40		
R46	10010-560	3	56 ohm, ¼ W, 5%	AB	CB5605
R47	10010-120	1	12 ohm, ¼ W, 5%	AB	CB1205
R48	10010-272	3	2.7 k, ¼ W, 5%	AB	CB2725
R49			Same as R46		
R50			Same as R39		
R51			Same as R44		
R52			Same as R35		
R53	10010-151	2	150 ohm, ¼ W, 5%	AB	CB1515
R54			Same as R41		
R55			Same as R53		
R56	10010-569	2	5.6 ohm, ¼ W, 5%	AB	CB5665
R57	10010-201	1	200 ohm, ¼ W, 5%	AB	CB2015
R58			Same as R56		
R59	10010-751	6	750 ohm, ¼ W, 5%	AB	CB7515
R60	10010-681	3	680 ohm, ¼ W, 5%	AB	CB6815
R61	10010-220	8	22 ohm, ¼ W, 5%	AB	CB2205
R62			Same as R61		
R63	10010-150	5	15 ohm, ¼ W, 5%	AB	CB1505
R64			Same as R63		
R65			Same as R61		
R66			Same as R61		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R67	10710-501	6	499 ohm, ¼ W, 1%	Corning	NA60
R68	10010-560	3	510 ohm, ¼ W, 5%	AB	CB5115
R69			Same as R67		
R70	10010-820	1	82 ohm, ¼ W, 5%	AB	CB8205
R71	10750-101	2	100 ohm, ¼ W, 1%	TI	CR¼, RN60D
R72			Same as R71		
R73	10010-561	2	560 ohm, ¼ W, 5%	AB	CB5615
R74			Same as R36		
R75	10010-223	5	22 k, ¼ W, 5%	AB	CB2235
R76	10010-101	4	100 ohm, ¼ W, 5%	AB	CB1015
R77			Same as R67		
R78	10010-331	3	330 ohm, ¼ W, 5%	AB	CB3315
R80	10011-102	2	1 k, ½ W, 5%	AB	EB1025
R81			Same as R76		
R82	10010-202	4	2 k, ¼ W, 5%	AB	CB2025
R83			Same as R82		
R84			Same as R46		
R85			Same as R57		
R86			Same as R59		
R87			Same as R59		
R88			Same as R59		
R89			Same as R82		
R90			Same as R82		
R91			Same as R76		
R92	10011-511	2	510 ohm, ½ W, 5%	AB	EB5115
R93			Same as R92		
R94			Same as R67		
R95	10750-550	1	55.5 ohm, ¼ W, 1%	TI	CR¼, RN60D
R96			Same as R67		
R97			Same as R48		
R98			Same as R48		
R99			Same as R18		
R100			Same as R34		
R101			Same as R29		
R102			Same as R29		
R103			Same as R34		
R104			Same as R18		
R105			Same as R75		
R106			Same as R22		
R107			Same as R35		
R108			Same as R35		
R109			Same as R22		
R110			Same as R75		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R111	10010-432	2	4.3 k, ¼ W, 5%	AB	CB4325
R112			Same as R111		
R113	10011-681	2	680 ohm, ½ W, 5%	AB	EB6815
R114			Same as R113		
R115	10010-102	4	1 k, ¼ W, 5%	AB	CB1025
R116			Same as R60		
R117			Same as R63		
R118			Same as R115		
R119	10010-222	2	2.2 k, ¼ W, 5%	AB	CB2225
R120	10010-752	3	7.5 k, ¼ W, 5%	AB	CB7525
R121			Same as R120		
R122			Same as R60		
R123			Same as R79		
R124			Same as R79		
R130			Same as R119		
R131	10710-362	2	3.57 k, ¼ W, 1%	Corning	NA60
R132	10750-163	1	15.9 k, ¼ W, 1%	TI	CR¼, RN60D
R133	10710-202	1	2 k, ¼ W, 1%	TI	CR¼, RN60D
R134	10010-241	1	240 ohm, ¼ W, 5%	AB	CB2415
R135	10010-390	1	39 ohm, ¼ W, 5%	AB	CB3905
R136	10750-323	2	31.8 k, ¼ W, 1%	TI	CR¼, RN60D
R137			Same as R136		
R138	10010-152	1	1.5 k, ¼ W, 5%	AB	CN1525
R139			Same as R61		
R140			Same as R63		
R141			Same as R63		
R142			Same as R61		
R143			Same as R67		
R145			Same as R115		
R146			Same as R120		
R147			Same as R59		
R148	10010-911	1	910 ohm, ¼ W, 5%	AB	CB9115
R149	10011-221	2	220 ohm, ½ W, 5%	AB	EB2215
R150			Same as R68		
R151			Same as R149		
R153	10010-471	4	470 ohm, ¼ W, 5%	AB	CB4715
R154			Same as R34		
R155			Same as R36		
R156			Same as R36		
R157	10010-362	2	3.6 k, ¼ W, 5%	AB	CB3625
R158			Same as R153		
R159			Same as R157		
R160			Same as R36		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
R161			Same as R36		
R162			Same as R153		
R163			Same as R73		
R164			Same as R153		
R165	10010-309	3	3 ohm, ¼ W, 5%	AB	CB3095
R166			Same as R36		
R167			Same as R36		
R168			Same as R61		
R169			Same as R165		
R170			Same as R165		
R171			Same as R61		
R172			Same as R115		
R173	10723-510	1	51 ohm, 2 W, 5%	Corning	Type C42
R501			Same as R36		
R502	10011-129	2	1.2 ohm, ½ W, 5%	AB	EB1295
R503			Same as R502		
R504			Same as R80		
R505			Same as R68		
R506			Same as R75		
R507			Same as R75		
R508	10010-821	1	820 ohm, ¼ W, 5%	AB	CB8215
R509			Same as R18		
R510			Same as R18		
R511			Same as R131		
R512			Same as R34		
R513	10690-562	1	5.62 k, 1/8 W, 1%	TI	RN60C
R515	10750-303	1	30 k, ¼ W, 1%	TI	CR¼, RN60D
R516			Same as R18		
Z3	12903-000	9	Operational Amplifier μA741C	FT	μA741C
Z4			Same as Z3		
Z5	12903-005	1	CA3039, Diode Array	RCA	CA3039
Z6			Same as Z3		
Z7	12903-002	1	Differential Comparator μA710C	FT	μA710C
Z8			Same as Z3		
Z9			Same as Z3		
Z10			Same as Z3		
Z11			Same as Z3		
Z12	12903-006	1	Transistor Array, CA3046	RCA	CA3046
Z13	C37000-903	1	Sine Shaper	DP	
Z501			Same as Z3		
Z502			Same as Z3		

REF. NO.	DATAPULSE PART NO.	QTY. USED	DESCRIPTION	MFR.	MFR. PART NO.
CR8	22164-000	15	DP16-0/1N3600		
CR9			Same as CR8		
CR10			Same as CR8		
CR11			Same as CR8		
CR12	12144-003	1	1N995, 30 mA, 15 PIV	Syl.	1N995
CR13			Same as CR8		
CR14	22314-919	3	1N757A, 9.1 V, 400 mW, 5%	Mot.	1N757A
CR15 thru CR23			Same as CR8		
CR501	22194-001	4	DP19-1, 100 V		
CR502			Same as CR501		
CR503			Same as CR501		
CR504			Same as CR501		
CR505			Same as CR14		
CR506			Same as CR14		
CR507			Same as CR8		
CR508	12154-201	1	1N936, 9 V, 0.5 W, 5%	Mot.	1N936



6. (6) INDICATES A FERRITE BEAD
5. SHOWN CONNECTED FOR NORMAL 115V/230VAC OPERATION.
   FOR 100V/200VAC OPERATION, REPLACE BRN WITH WHT & ORN WITH WHT/RED
   FOR 125V/200VAC OPERATION, REPLACE BRN WITH GRY & ORN WITH BLK
4. Q503 & Q504 ARE MOUNTED ON BACK PANEL.
3. [BOXED] LETTERS INDICATE SPECIFIC LABELED POINTS ON P.C. BOARD.
2. ALL CAPACITOR VALUES ARE IN µF
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 5%
NOTES: UNLESS OTHERWISE SPECIFIED

DS501	D5501
F501	F502
Q501	Q504
R501	R516
C501	C504
CR501	CR508
T501	T501
S501	S502
F501	F501

FIRST USED LAST USED QUANTITY
REFERENCE DESIGNATIONS

REF ASSY DWG 37000 - B83

APPLICATION	401		

F. QUON 10/69

SCHEMATIC POWER SUPPLY M 401

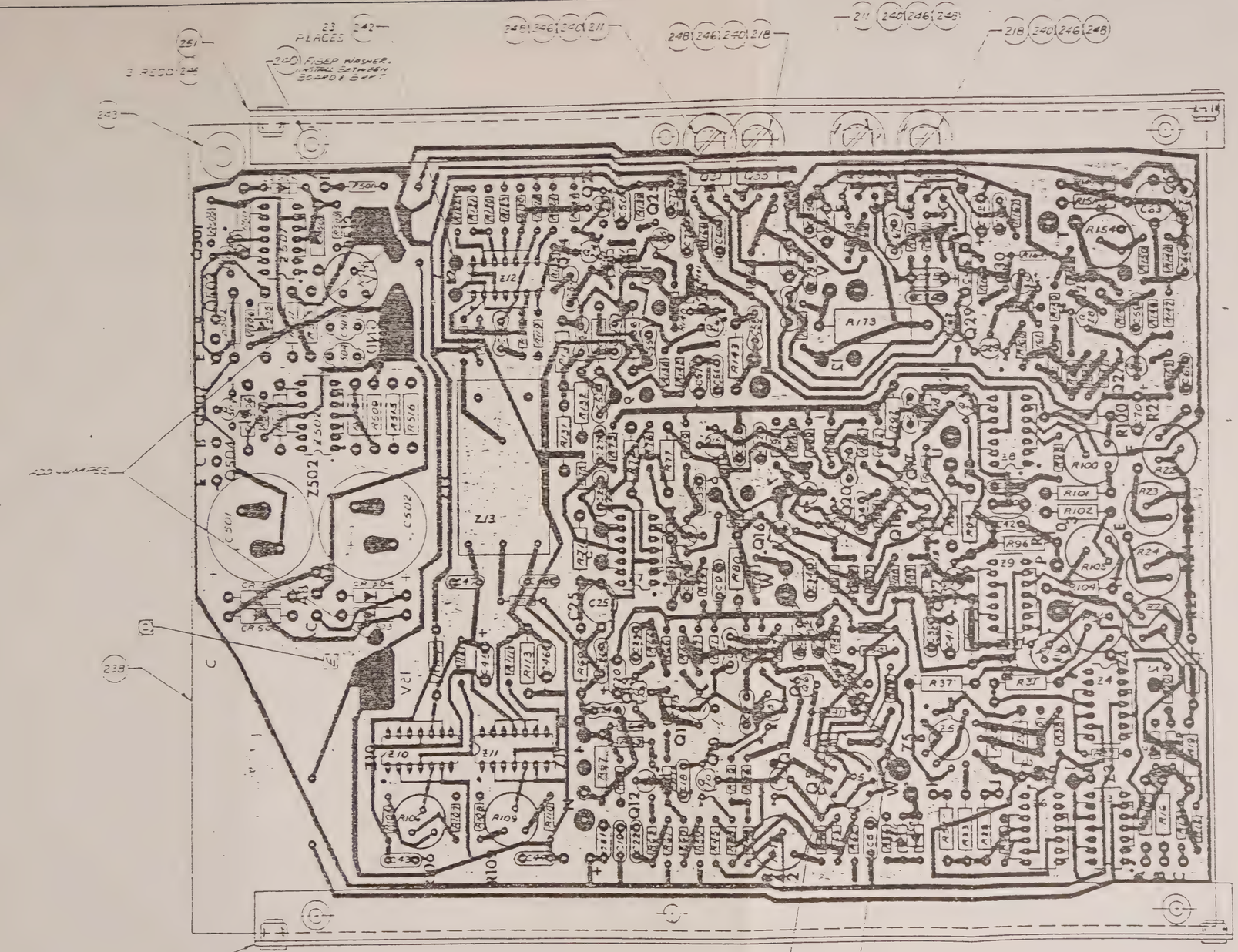
SCALE NONE

40000-395

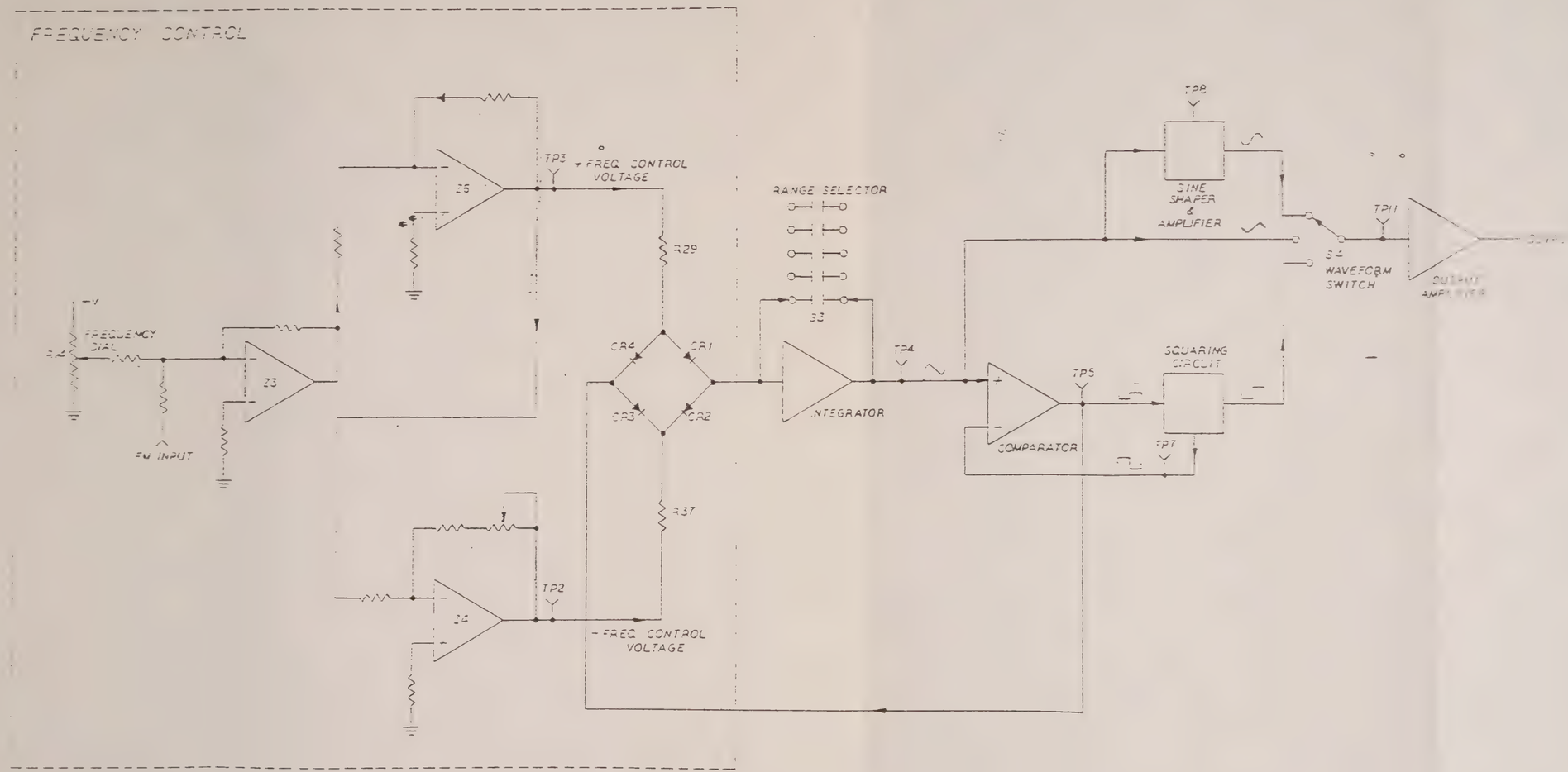
E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
3527A	7-19-71	40000-395 37000-883	Remove R501 from "AD" to ground and replace with a wire jumper.
3562	8-16-71	37000-883	Change R21 from 4.53 k, 1%, P/N10750-452 to 4.32 k, 1%, P/N10710-432.
3585	9-9-71	Manual	Change paragraph 4.4.7 step (c) to read: "Set the AMPLITUDE control fully counterclockwise and the Impedance/Attenuator switch to 50 ohm/—40 dB. Verify that the voltmeter decreases more than 80 dB. Change paragraph 4.4.8 step (d) to read: "Set the frequency dial to 0.02 (first dial increment)....." Add note after step (d): NOTE: If no output is present, rotate dial slightly counterclockwise.
3591	9-14-71	Manual	If potentiometer R8 and resistor R9 are present, perform the following step after paragraph 4.3.5 step (r): Set the FREQUENCY RANGE Hz selector to X1 and position the frequency dial to 0.2. Adjust the 5 k potentiometer for a reading of 5 seconds ±100 ms. Set the FREQUENCY RANGE Hz selector to X10 k and adjust R22 (if necessary) for 2 kHz ±2 Hz. Repeat the above two (2) steps until both readings remain within the specified tolerance. Repeat paragraph 4.3.5 in its entirety.
3800	2-15-72	37000-883	Change R17 from 2.7 megohm, P/N10010-275 to 1.3 megohm, P/N10010-135.
3808	2-15-72	Manual	In paragraph 5.2.2 change "Q5/Q8 to Q6/Q8". Change C8 and C16 to C8 and C18.
3913	4-24-72	40000-410	Add asterisk (*) to R8 and R9. *"Note, may or may not be present."
3933	5-12-72	40000-395	Change R514 from 10 ohm, ¼ W to 56 ohm, ¼ W, P/N10010-560.
3974	6-28-72	37000-883	There are two (2) CR12's shown on the schematic. CR12 which is closest to CR11 should be changed to CR10.
3951	6-3-72	40000-395	For 230 volt operation, change the current value of the fuse to the next size over ¾ the current value at 115 volt operation.
4131	9-19-72	37000-883	Delete IC Socket, P/N15140-005. Change C80, P/N11077-509 from 5 pF, 500 V, 5% to 5 pF, 500 V, 10%.
4207	11-13-72	40000-395	Void E.O. 3951 — For 230 volt operation, change the rating of the fuse to ¾ the value of the 115 V rating. Replace with nearest higher standard value (i.e.), 115 V = 1 amp, 230 V = ¾ amp.

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
4256	1-5-73	Manual	Add the following paragraph to Section I, following Frequency Stability: Temperature Stability: The frequency will not drift more than 0.05% per degree centigrade.
4290	2-21-73	Manual	Change Table 4-1 - Dial Accuracy Check Dial Range Counter Indication from 2 X1 490 ms to 520 ms to 2 X1 490 ms to 510 ms
4342	4-6-73	40000-410	Add asterisk to R163, P/N10010-561 [illegible] adjusted value.
4358	4-17-73	40000-410 37000-883	Change Q31 and Q34 from MPS 052, P/N12605-017 to Silicon, PNP, 2N2904A, P/N12605-002. Add Heat Sink, NF209, P/N15550-113 and mounted on two transistor pads, P/N15550-207.
3585A	5-8-73	Manual	Reference E.O. 3585, 9-9-71, Section IV, paragraph 4.4.8, step (d) add note: If no output is present, rotate dial slightly counterclockwise until minimum frequency is obtained.
4445	7-10-73	40000-410	Change R34, R100, R103, R154, R512 from 1 k, ¼ W, 20%, P/N10437-102 to 1 k, ½ W, 20%, P/N10435-102. Change R25 and R42 from 10 k, ¼ W, 20%, P/N10437-103 to 10 k, ½ W, 20%, P/N10435-103.
4512	9-7-73	40000-410 37000-883	Change R163 from 560 ohm, ¼ W, 5%, P/N10010-561 to 10 ohms, ¼ W, 5%, P/N10010-100.
4616	12-10-73	Manual	Section IV, Table 4-1, page 4-10: Change 99.90 kHz to 101.0 kHz .TO 99.00 kHz to 101.0 kHz.

REVISIONS				
LTR	ECN	DESCRIPTION	DATE	APPROVED
A		INITIAL RELEASE E.O. 1495	11-MAR-70	JR
B		SEE E.O. 1678	11-MAY-70	HALL
C		INCORP E.O. 1752	10-JUN-70	PMC
D		INCORP E.O. 1822	7-JUL-70	JR
E		INCORP E.O. 1911	7-JUL-70	JR



REVISIONS				
ECA	SYM	DESCRIPTION	DATE	APPROVED
	—	INITIAL REL E.O. 1612	12-27-72	



41000-222

NOTES: UNLESS OTHERWISE SPECIFIED

401			
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		CITY RECD	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ON: 2 PLACE DEC. ±; 1 PLACE DEC. ±; ANGLES ±; MATERIAL; FINISH; DO NOT SCALE DWG.

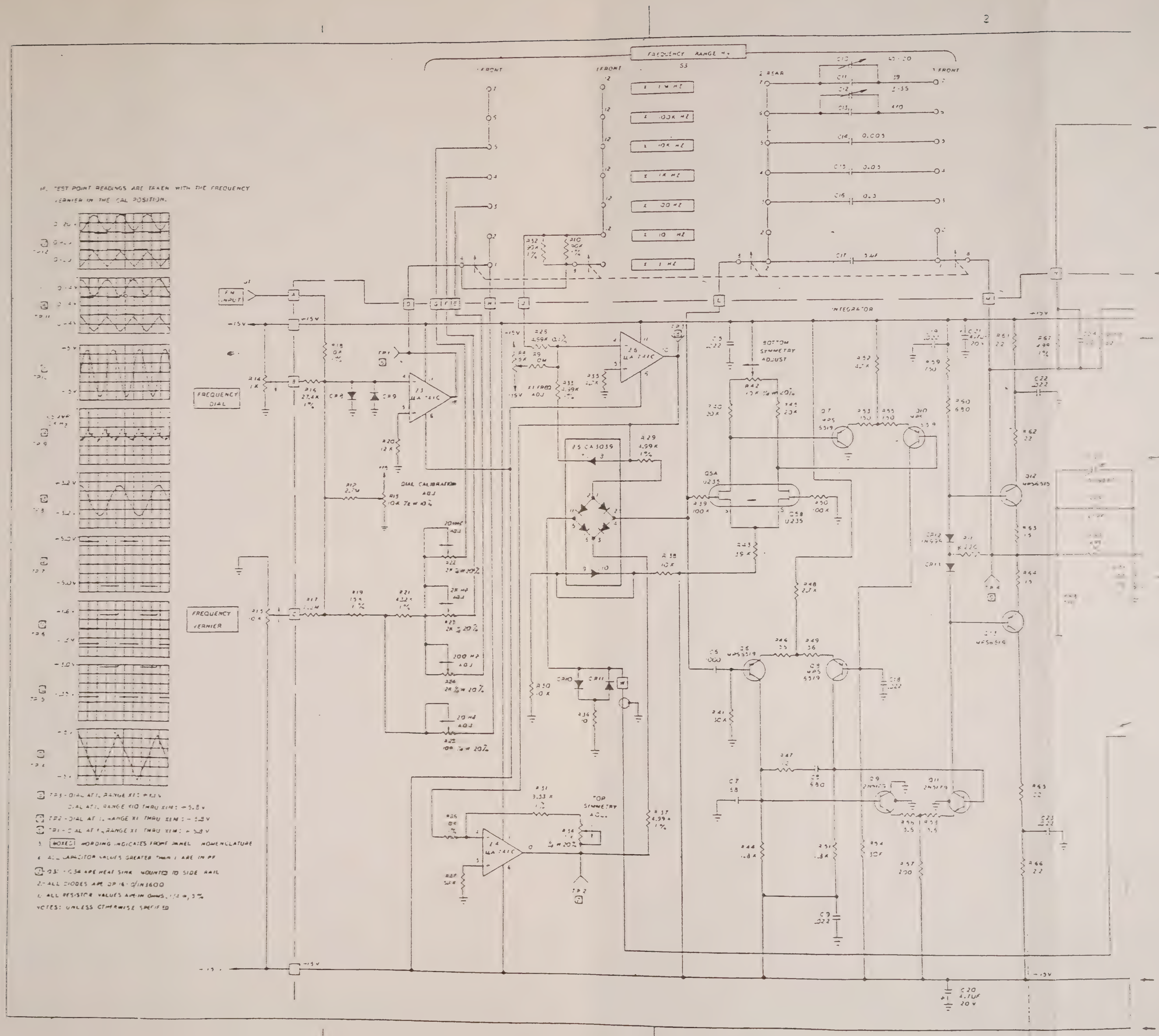
DRAWN 3-13-70 | CHECKED | APPROVED | APPROVED | APPROVED | RELEASED E.O. 1612 12-27-72

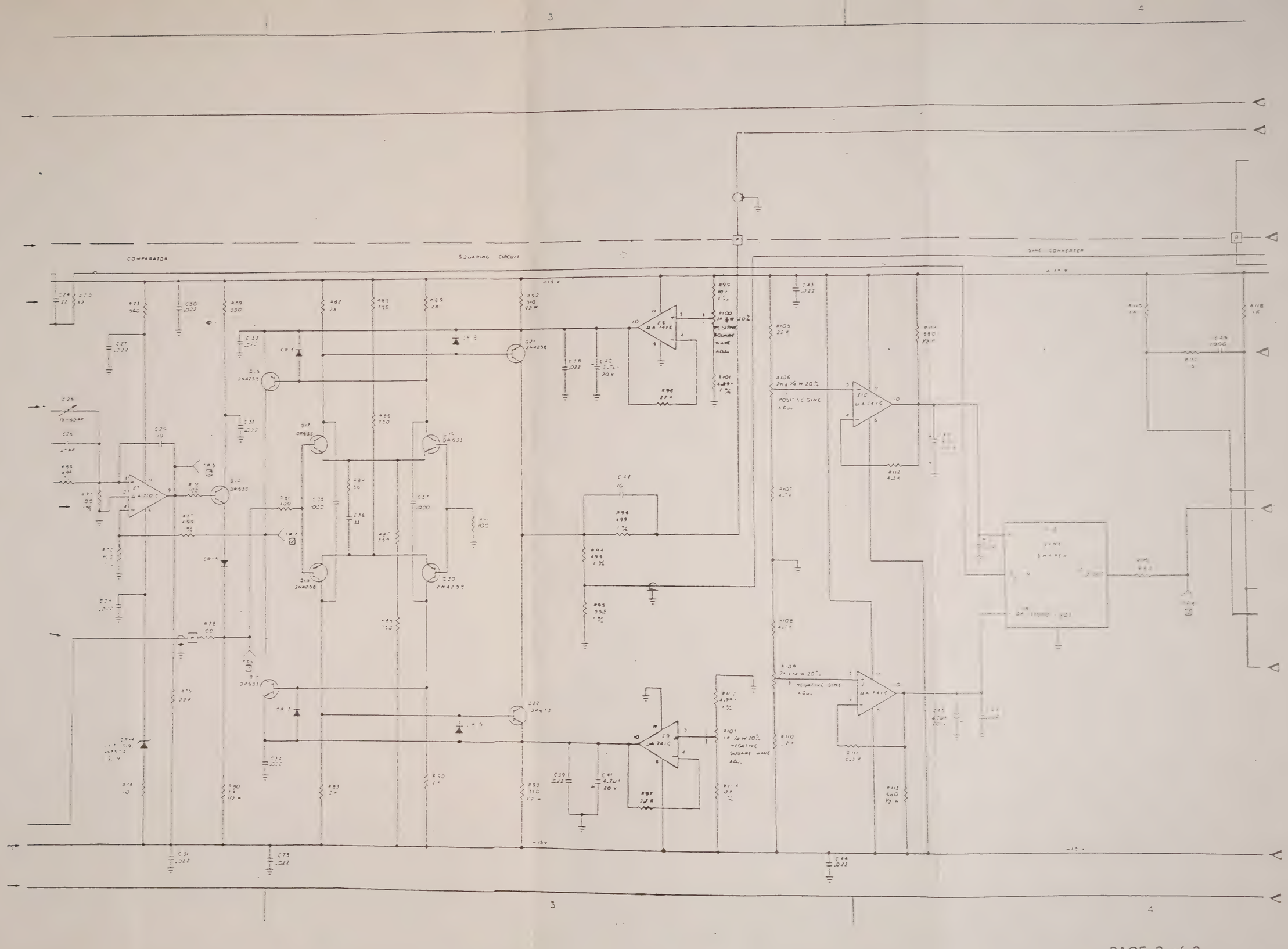
TITLE: BLOCK DIAGRAM - FUNCTION GENERATOR MODEL 401

DATAPULSE, INC. CULVER CITY, CALIFORNIA

SIZE D | 41000-222

SCALE — | CODE 19623 | SHEET 1 OF 1


FREQUENCY RANGE Hz
S3
X 1M HZ
X 100K HZ
X 10K HZ
X 1K HZ
X 100 HZ
X 10 HZ
X 1 HZ
FM INPUT
FREQUENCY DIAL
FREQUENCY VERNIER
DIAL CALIBRATION ADJ
BOTTOM SYMMETRY ADJUST
TOP SYMMETRY ADJ
INTEGRATOR
TEST POINT READINGS ARE TAKEN WITH THE FREQUENCY VERNIER IN THE CAL POSITION.
BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
ALL CAPACITOR VALUES GREATER THAN 1 ARE IN PF
ALL DIODES ARE 1N4148
ALL RESISTOR VALUES ARE IN OHMS
NOTES: UNLESS OTHERWISE SPECIFIED


COMPARATOR
SQUARING CIRCUIT
SINE CONVERTER
+15 V
-15 V
POSITIVE SINE ADJ.
NEGATIVE SINE ADJ.
NEGATIVE SQUARE WAVE ADJ.
SINE SHAPER
SINE THRESHOLD ADJ.
3
4

SINE AMPLIFIER

OUTPUT AMPLIFIER

+15V

-15V

AMPLITUDE

OFFSET

NARROW

WIDE

ATTENUATOR

50Ω OUT

600Ω OUT

TRIM CAPACITOR

GAIN ADJ.

SCHEMATIC — FUNCTION GENERATOR 401

AFE 4037 DWG - 37010C-B&S

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